Section 2. EOS Mission Overview

The Earth Observing System (EOS) -- a series of polar-orbiting and low-inclination satellites for long-term global observations of the land surface, biosphere, solid Earth, atmosphere, and oceans -- is the centerpiece of MTPE. In tandem with EOS, the polar-orbiting and mid-inclination platforms from Europe, Japan, and the U.S. National Oceanic and Atmospheric Administration (NOAA) form the basis for a comprehensive International Earth Observing System (IEOS).

2.1 Mission to Planet Earth

Scientific research shows that the Earth has changed over time and continues to change. MTPE is NASA's contribution to the U.S. Global Change Research Program (GCRP). The GCRP will establish a basis for national and international policy regarding possible changes in the Earth's climate; the overall purpose of MTPE is to determine the extent, causes, and regional consequences of these changes. NASA's research efforts are primarily focused on space-based studies of the Earth as an integrated system, to provide the scientific basis for understanding global change.

MTPE is an evolutionary program composed of two mission phases. Phase I consists of observations from ongoing and near-term satellites operated by NASA, other U.S. agencies, and international partners to provide data for use in monitoring the global climate and other Earth system processes that lead to global change. The Tropical Rainfall Measuring Mission (TRMM) and the Landsat 7 spacecraft are included among the large number of Phase I missions. Numerous air and ground observations of the Earth will also be performed during Phase I. During Phase II, the global observations of Phase I will continue and will be augmented by more coordinated and comprehensive observations from spacecraft of the various EOS series over a 20-year period.

2.2 EOS Program Mission Objectives

The goal of the EOS Program is to advance scientific understanding of the entire Earth system on a global scale, by developing a deeper understanding of the components of that system, the interactions among them, and how the Earth system is changing. The program's objectives in support of this goal are

a. To create an integrated scientific observing system emphasizing climate change, to enable multi-disciplinary study of the Earth's critical, life-enabling, interrelated processes involving the atmosphere, oceans, land surface, polar regions, and solid Earth, and the dynamic and energetic interactions among them.

b. To develop a comprehensive data and information system, including a data retrieval and processing system, to serve the needs of scientists performing an integrated multi-disciplinary study of the Earth and to make MTPE data and information publicly available.

c. To acquire and assemble a global data base for remote sensing measurements from space over a decade or more, to enable definitive and conclusive studies of Earth system attributes.

2.3 Principal EOS Mission Requirements

The principal EOS mission requirements are to:

a. Establish a spaceborne observation capability lasting over 20 years.

b. Maintain continuity of essential global change measurements from ongoing and planned missions.

c. Obtain at least one decade of overlapping, calibrated data from the full EOS space system.

d. Characterize the highly variable aspects of the Earth's global system every one to three days.

e. Make all NASA Earth science data readily and promptly available.

f. Support the communication and exchange of research findings based on EOS data or produced by EOS investigations.

g. Support the overall U.S. GCRP.

EOS mission requirements also include general level 1 requirements to meet standards in communications and data delivery; provide capabilities for science investigation, end-to-end system testing, and international technology transfer; and minimize the generation of orbital debris.

2.4 Major EOS Segments

EOS consists of three major segments: a space system, a ground system, and an integrated scientific research program.

a. The space system provides new capabilities for acquiring global Earth sciences data.

b. The ground system, primarily the EOSDIS, makes the full suite of EOS and other NASA Earth science data accessible to the broad science/user community.

c. The integrated scientific research program uses data from EOS and non-EOS missions to investigate the Earth system.

Figure 2.4-1 represents the relationships among these segments.

2.4.1 Space System

The EOS space system consists of a series of predominantly polar-orbiting spacecraft. The United States, the European Space Agency (ESA), and Japan's National Space Development Agency (NASDA) are scheduled to fly EOS missions. The EOS-era missions currently planned are shown in Table 2.4-1.

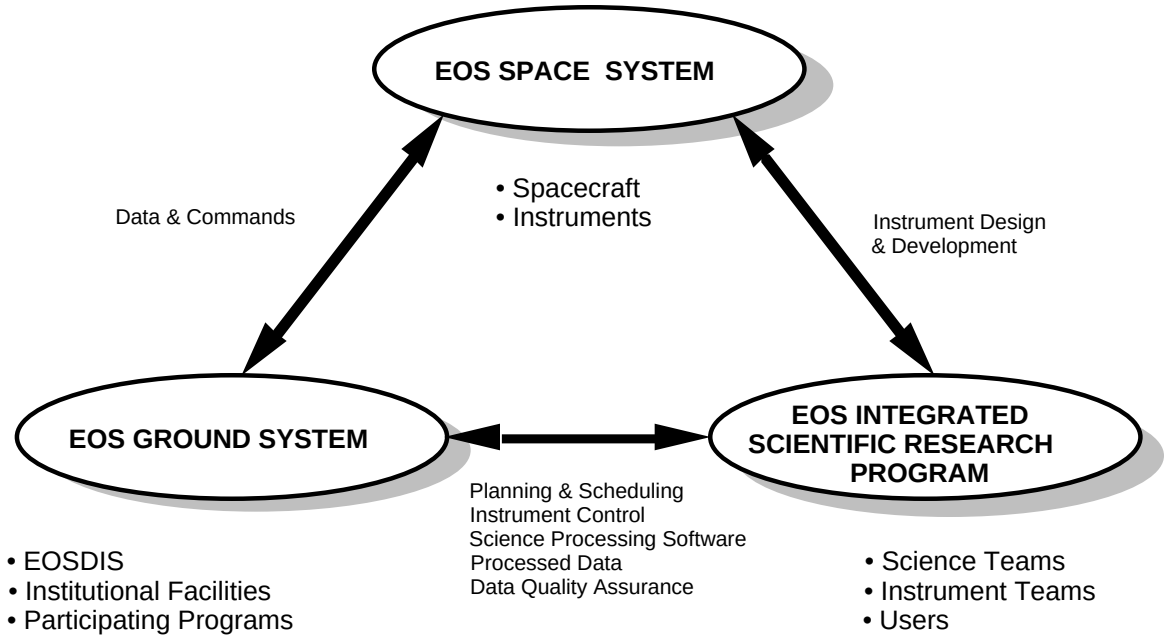

Figure 2.4-1 Major EOS Segments

Table 2.4-1 Planned EOS-Era Missions

Country	Program	Spacecraft	Launches (Tentative)
United States	Earth Observing System (EOS)	AM series	1998, 2004, 2010
		PM series	2000, 2006, 2012
		LALT series	2003, 2009, 2015
		CHEM series	2002, 2008, 2014
ESA	Polar-Orbit Earth Observation Mission (POEM)	ENVISAT series	1998
		METOP series	2000
Japan	Japanese Earth Observing System (JEOS)	ADEOS IIA	1999
		ADEOS IIB	to be scheduled
		TRMM-2	2000

Four series of U.S. EOS spacecraft are planned, each with a different flight configuration based on scientific measurement objectives. During EOS's projected 20-year operational lifetime as many as four spacecraft (one from each series) may be operating simultaneously. In addition, two spacecraft from the same series may be in orbit during a spacecraft cross-over replacement period of up to six months. The major science objectives for each series is shown in Table 2.4-2. More detailed

Table 2.4-2 Summary of EOS Science Objectives

Series	Major Science Objectives
AM	Characterization of the terrestrial and oceanic surfaces
	Clouds, aerosols, and radiation
	Radiative balance
	Sources and sinks of greenhouse gases
PM	Cloud formation, precipitation, and radiative balance
	Terrestrial snow and sea ice
	Sea-surface temperature and ocean productivity
LALT	Ice sheet mass balance
CHEM	Atmospheric chemical species and their transformations

information about each series is provided in the *Execution Phase Project Plan for Earth Observing System (EOS)* and in the documentation associated with each mission.

The scientific instruments for the NASA EOS spacecraft are divided into two instrument classes, facility and principal investigator (PI). Facility instruments measure variables useful to a wide range of science disciplines; PI instruments observe more specific phenomena. Many instruments have been selected or are in
the process of being selected to be flown on the U.S. EOS series of spacecraft. In addition to these EOS spacecraft, EOS-funded Flight of Opportunity instruments will be flown on other U.S. and international spacecraft. For details about the EOS instruments, see the *1995 MTPE EOS Reference Handbook.*

The AM-1 spacecraft will use the Space Network (SN) Tracking and Data Relay Satellite System (TDRSS) as the primary space-to-ground communications link. It will also have an X-band capability that will be used in the event of a failure in the primary communications link. For all subsequent NASA EOS spacecraft, the primary communications link will be an X-band downlink to dedicated EOSDIS ground stations. The X-band sites will also provide S-band command and control links, although all EOS spacecraft will retain capabilities for using the SN for command and control purposes. EOS spacecraft will utilize the Deep Space Network, Ground Network, and Wallops Orbital Tracking Station for emergency communications.

The *EOS Mission Operations Concept* provides a more detailed discussion of EOS instrument complements, flight configurations, launch and spacecraft orbits, spacecraft design concepts, and space-to-ground communications.

2.4.2 Ground System

The EOS Ground System (EGS) is an operational assembly of facilities, networks, and systems which collectively comprise the infrastructure necessary to acquire, transport, archive, process, distribute, and organize EOS and other NASA Earth science data and make it accessible to the broad science/user community. The EGS comprises EOS program-specific components and capabilities called the EOSDIS, and institutional service providers and other participating programs that are not solely dedicated to the EOS program. Figure 2.4-2 identifies the EGS elements that make up the EOSDIS, and the EOSDIS interfaces with the remaining EGS elements. The role of each element is summarized in Table 2.4-3, and further discussed in Section 3.1.

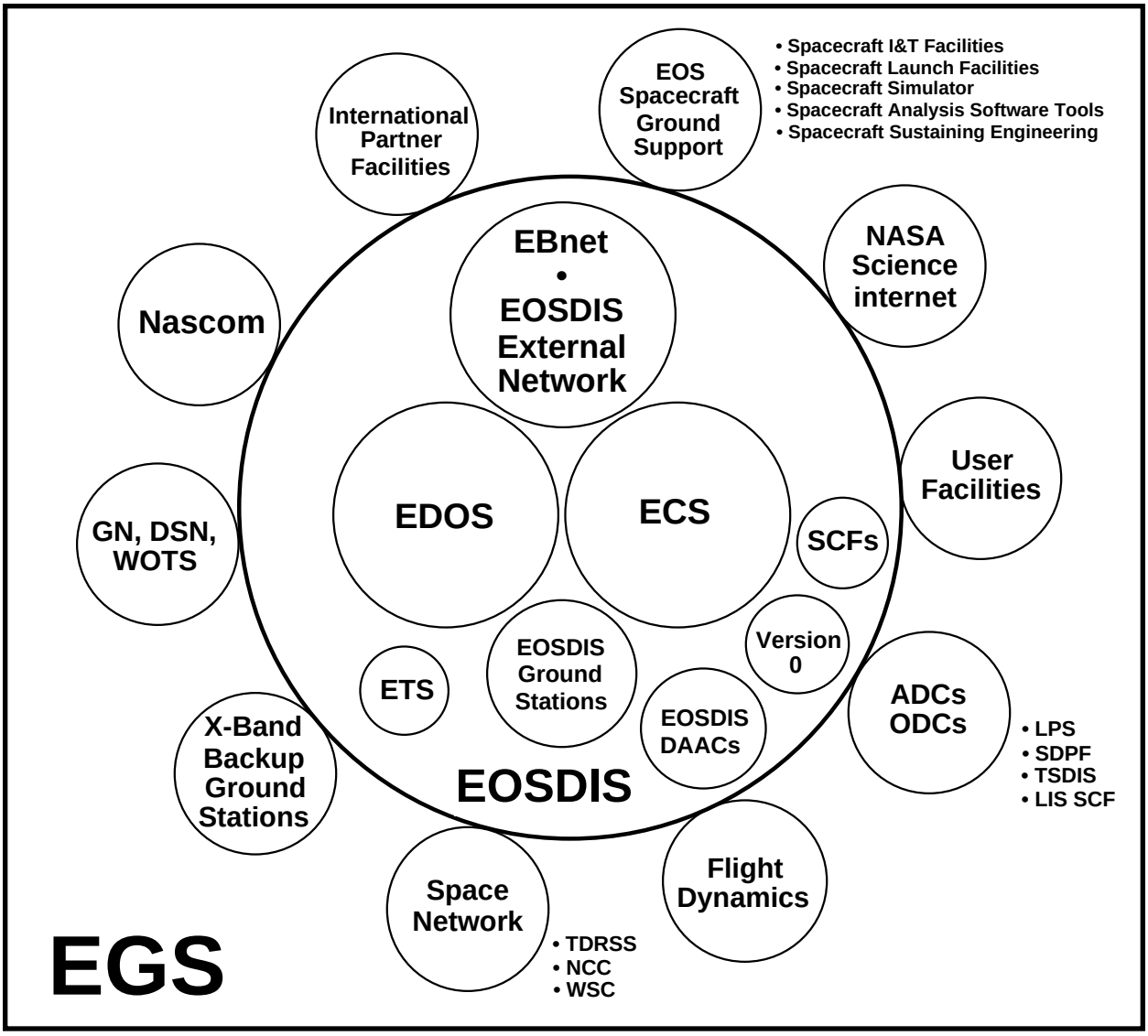

Figure 2.4-2 EOS Ground System Elements and EOSDIS Interfaces

Table 2.4-3 Summary of Roles of EGS Elements

EGS Element	Role
EOSDIS	
• EOSDIS Core System (ECS)	Provides EOS flight operations; science data processing; and EOSDIS communications and system management
• Distributed Active Archive Centers (DAACs)	Provides production, archive, and distribution of EOS and non-EOS science data products, and user support
• Version 0	Provides a working prototype of selected key EOSDIS services with some operational elements
• Science Computing Facilities (SCFs)	Provides science data processing software/algorithms, data product quality assessment, and user support
• EOS Data and Operations System (EDOS)	Provides EOS data capture, level 0 processing, and backup archive
• EOSDIS Backbone Network (EBnet) and External Network	Provides EGS mission operations communication services and science operations communication services
• EOSDIS Test System (ETS)	Provides test data generation and EGS element simulation capabilities
• EOSDIS Ground Stations	Provides space to ground communications services for post-AM-1 missions
Institutional facilities	
• Flight Dynamics	Provides orbit and attitude data, and orbit adjust and maneuver computations for EOS spacecraft
• Nascom	Provides communications services between the White Sands Complex (WSC) and EGS elements
• Space Network	Provides TDRSS services for AM-1 spacecraft; coordinates other ground station scheduling
• Ground Network (GN), Deep Space Network (DSN), Wallops Orbital Tracking Station (WOTS)	Provides backup low-rate communications services
• X-Band Backup Ground Stations	Provides backup science data communications services for AM-1
Participating Programs	
• EOS Spacecraft Ground Support	Provides real-time spacecraft simulations, generation and test of flight software updates, integration and test facilities, operational launch support services, and spacecraft sustaining engineering facilities and services
• International Partner Facilities	Includes interfaces with international partner facilities such as the ASTER Ground Data System (GDS), and the NASDA Earth Observation Information System (EOIS)
• Affiliated Data Centers (ADCs) & Other Data Centers (ODCs)	Provides selected Earth science data and metadata to DAACs for archive and user access; examples include the Landsat Processing System (LPS), and the TRMM Science Data and Information System (TSDIS)
• User Facilities	Provides user access to EOSDIS science data
• NASA Science Internet (NSI)	Provides external communications services between EOSDIS and EOSDIS users

2.4.3 Integrated Scientific Research Program

The EOS integrated scientific research program is comprised, in part, of a large, geographically distributed science user community. Scientists determine the observations to be made; instrument engineering teams build the instruments to collect the data; science teams plan and schedule the use of the instruments; and science users provide the EGS with the science algorithms for generating data products and evaluating the quality of the generated products. Finally, scientists analyze the data from the EOS instruments, publish research results, and make recommendations to the global change research community.

EOS users, who represent a broad range of science disciplines, operations experience, and computer systems skills, are divided into three categories. The first category, EOS investigators, consists of the investigators and research staff under contract with NASA to participate in the EOS program. This group includes the PIs and co-investigators associated with the PI-class instruments, the team leaders and team members associated with facility instruments, and the interdisciplinary investigators associated with two or more instruments. The second category consists of the large group of non-EOS affiliated science users, such as U.S. and international science researchers located at various government agencies, educational institutions, and commercial organizations. The third category constitutes a more diverse group of users who are expected to use EOS and other MTPE data for purposes other than science investigations or research. These purposes include, for example, policy-making; the operation, maintenance, and management of the EGS; commercial applications; and education.

2.5 International Participation

Because the EOS Program is part of a global effort, the participation of international users and organizations is important in all phases of EOS activities. U.S. scientists work closely with their international counterparts in planning the World Climate Research Program (WCRP) and WCRP specialized global research programs that are central components of the U.S. GCRP. The Earth Observations International Coordination Working Group is the forum within which the U.S., Europe, Japan, and Canada discuss, plan, and negotiate the international cooperation essential for implementation of the IEOS Program.

Several foreign space agencies, including ESA, the Canadian Space Agency, Japan's NASDA, and the European Organization for the Exploitation of Meteorological Satellites, are planning Earth observing missions that complement the NASA EOS program. As part of this cooperative effort, international instruments will be flown on U.S. EOS spacecraft and U. S. instruments will be flown on international spacecraft .

2.6 General Operations Concept

The mission life-cycle for each EOS spacecraft includes five phases: prelaunch, launch, activation, mature operations, and cross-over operations and deactivation. This section describes a general operations concept for EOS missions during the mature operations phase of the mission lifecycle. Figure 2.6-1 presents a high-level view of the EOS mission general operations concept in terms of the following major ground system functions.

a. Spacecraft command and control,

b. Data capture and level 0 processing,

c. Science data processing, archiving, and distribution,

d. Communications and systems management, and

e. Data communications.

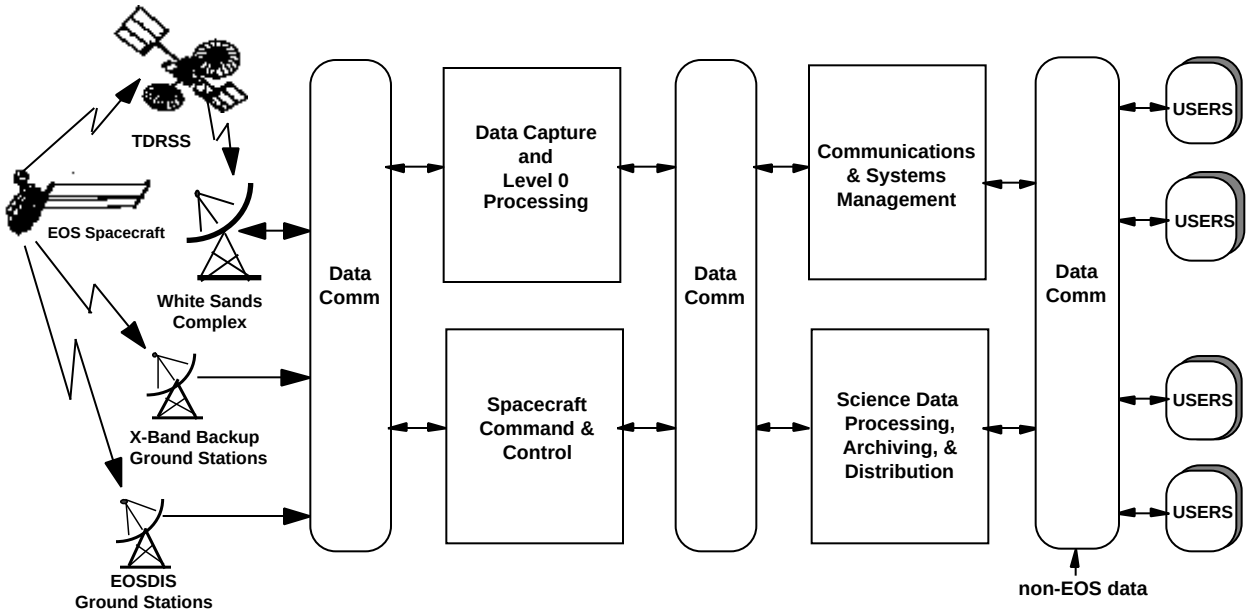

Figure 2.6-1 EOS Mission General Operations Concept

The activities illustrated in Figure 2.6-1 are performed during the mature operations phase for each EOS spacecraft. Communications with EOS spacecraft are accomplished through either the TDRSS or EOSDIS ground stations. The X-Band backup ground stations provide backup science data communications for AM- 1. The raw spacecraft data are captured, processed into a level 0 format, and stored in a backup archive. Level 0 data are transported to science data processing facilities, where standard data products and other special data products are produced, archived, and distributed to EOS investigators and other users via external networks and other interfaces. These facilities also ingest and archive non-EOS Earth science data to make these data available to investigators and support special product generation.

The EGS supports EOS mission operations by performing spacecraft and instrument command and control, including mission planning and scheduling and monitoring the health and safety of the spacecraft and instruments; and by providing internal communications and EGS status monitoring and coordination.

The EGS is discussed in more detail in Section 3. EGS operations are described in Section 4.

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